A1250-1
11/23/88

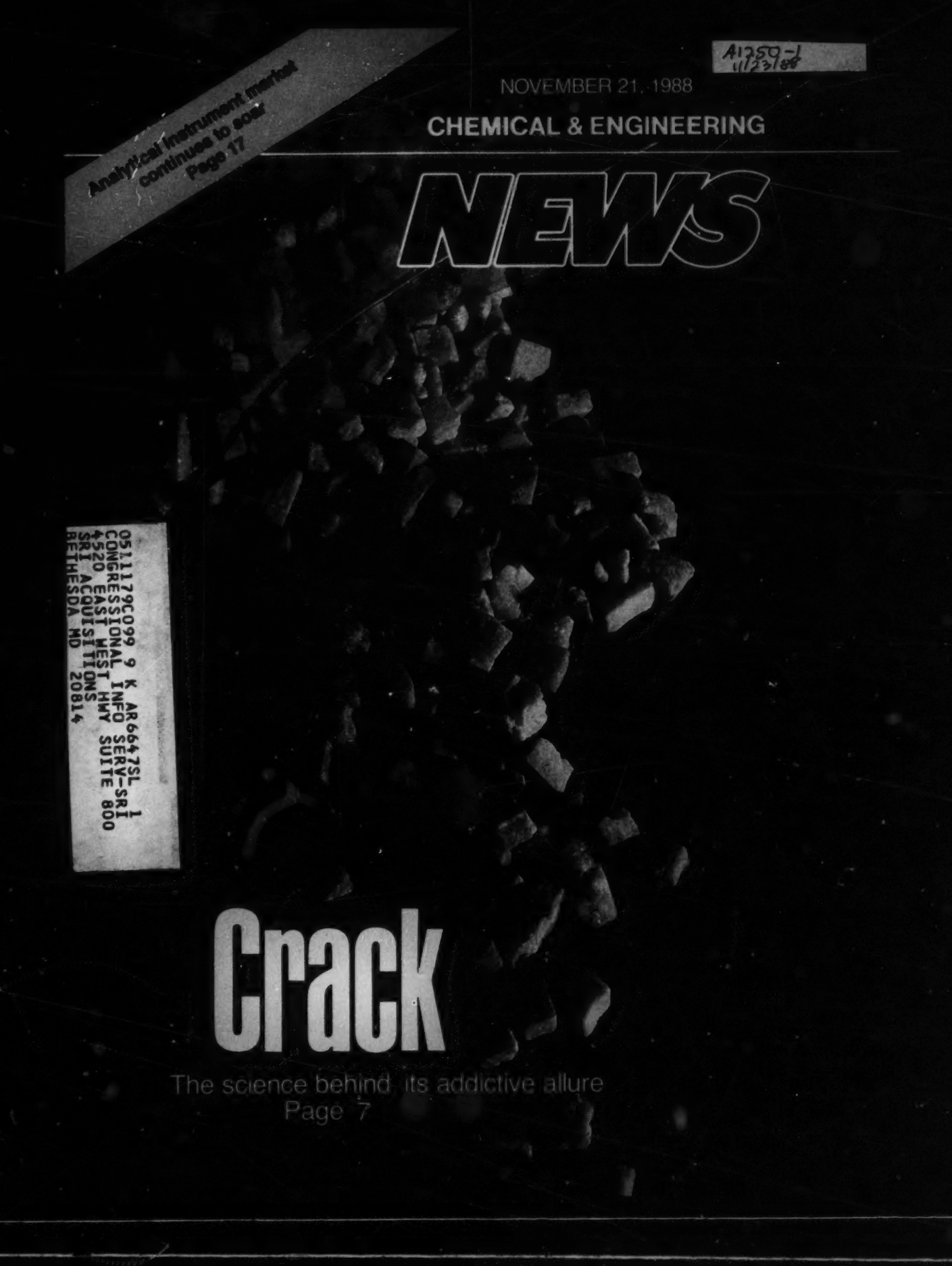
NOVEMBER 21, 1988

CHEMICAL & ENGINEERING

NEWS

Analytical instrument market continues to soar
Page 17

0511179C099 9 K AR6647SL 1
CONGRESSIONAL INFO SERV-SRI
4520 EAST WEST HWY SUITE 800
SRI ACQUISITIONS
BETHESDA MD 20814



Crack

The science behind its addictive allure
Page 7

CHEMICAL & ENGINEERING
NEWS

Volume 66, Number 47
CENEAR 66 (47) 1–60
ISSN 0009-2347

NOVEMBER 21, 1988

News of the Week

■ **Visit to the U.S. by Soviet Nobel Peace Prize Laureate and human rights leader Andrei D. Sakharov included meeting with Edward Teller, other dramatic and symbolic moments.** Page 4

■ **Polychlorinated biphenyls have been proven to be biodegradable, confirming the hypothesis they are being dechlorinated in Hudson River sediments.** Page 5

■ **Japanese petrochemical industry delegation visits ACS as part of trip to study chemical public information programs in the U.S.** Page 5

■ **Du Pont will market mice with cancer-causing genes for cancer research, marking the first commercialization of genetically engineered animals.** Page 6

■ **Expanded superconductor R&D program is sorely needed, or U.S. faces prospects of purchasing these materials for defense purposes from foreign sources such as Japan, task force finds.** Page 6

Cover: Packet of crack cocaine at Ft. Lauderdale police station. Photo by Steve Starr/The Picture Group

Letters 2

Concentrates
Business 15
Government 22
Science/Technology 26

The Departments
ACS Comment 35
Newscripts 60

Business

The market for analytical instruments continues its fast growth, sparked by increasing demand for chemical analysis, strong exports, new and better techniques. Page 17

Japanese chemical industry's current impressive performance stems from the robust domestic demand for basic chemical products. Page 21

Government

Election causes little change in Congress, with the Democrats winning a few more House seats and one additional Senate seat. Page 23

Political battle begins over decision to site Superconducting Super Collider in Texas, as representatives from rejected states question selection process. Page 24

Technology

Crucial role of supercomputers in materials science research is emphasized in a report by the National Research Council. Page 27

China plans to establish a network of 12 analytical chemistry laboratories. Page 28

Books

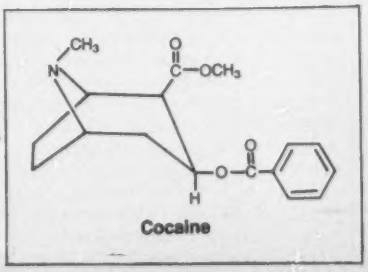
"Messengers of Paradise: Opiates and the Brain" by Charles Levinthal, relates story of the race for breakthroughs on the brain's endogenous opioid system. Page 33

ACS News

The society's fund-raising effort, Campaign for Chemistry, has a new chairman and is progressing toward its goals. Page 36

Awards

ACS award winners: Krigbaum, Lagowski, Levitt, Macfarlane, Mandelkern, Marks, Marsh, McLafferty, and Olah. Page 41



Cocaine

News Focus

Scientists struggling to understand and treat cocaine dependency are frightened by the dimension that crack cocaine has added to the problem of cocaine abuse. Page 7

Chemical & Engineering News

1155—16th St., N.W., Washington, D.C. 20036

Editor: Michael Heylin
Assistant Managing Editors: David M. Kiefer, James H. Krieger, Janice R. Long, Donald J. Soisson, William J. Storck. **News Editor:** Wilbert C. Lepkowski
Staff Editor: Ernest L. Carpenter
Senior Editors: New York: Earl V. Anderson, Stephen C. Stinson; Chicago: Joseph Haggin; Washington: Doron Dagani, Lois R. Ember, Rebecca L. Rawls, Pamela S. Zurer
Associate Editors: Stuart A. Borman, Mairin B. Brennan, Bette Hileman, Richard J. Seltzer
Service Departments Editor: Dolores Miner
Editing Services: Anne Riesberg (Head), Arlene Goldberg-Gist (Editorial Assistant), Patricia Oates (Administrative Assistant)
News Bureaus: Northeast News Bureau: (201) 966-8300 Marc S. Reisch (Assistant Editor), Ann M. Thayer (Assistant Editor), Rachel Eskenazi (Administrative Assistant). Chicago: (312) 256-4143 Ward Worthy (Head). Houston: (713) 973-8161 Bruce F. Greek (Head). Washington: (202) 872-4495 David J. Hanson (Head). West Coast: (415) 653-3630 Rudy M. Baum (Head). **Foreign Bureau:** London: (01) 540-0414 Dermot A. O'Sullivan (Head), Patricia L. Layman (Associate Editor)
Graphics and Production: Leroy Corcoran (Manager). Alan Kahan (Art Director). Barbara Fryer (Production/Art Director). Linda Mattingly (Staff Artist). Diane Kelly (Costing). **Business Manager:** Arthur Poulos
Circulation Development: Claud K. Robinson
ADVISORY BOARD: William J. Bailey, Jacqueline K. Barton, Ernest H. Drew, Harry G. Drickamer, A. Nicholas Filippello, Vincent L. Gregory Jr., Adam Heller, John D. Holmfeld, Isabella Karle, Koji Nakanishi, Richard Nicholson, Howard A. Schneiderman, Ellen K. Silbergeld, Howard E. Simmons, Robert M. Simon, William P. Slichter

Published by
AMERICAN CHEMICAL SOCIETY
(202) 872-4600; TDD (202) 872-8733
John K Crum, Executive Director

PUBLISHING BOARD: Ned D. Heindel (*Chairman*); *Board of Directors Chairman:* Ernest L. Eliel; *President:* Gordon L. Nelson; John H. Nelson; Louis D. Quin; Jean'ne M. Shreeve; and Barbara G. Wood

© Copyright 1988, American Chemical Society

Subscription & Member Record Service: Send all new and renewal subscriptions with payments to: Controller, ACS, P.O. Box 28597, Central Station, Washington, D.C. 20005. Correspondence and telephone calls for changes of address, claims for missing issues, subscription service, status of records and accounts should be directed to: Manager, Membership & Subscription Services, ACS, P.O. Box 3337, Columbus, Ohio 43210; (614) 421-3776.

For changes of address, include both old and new addresses with ZIP code numbers and mailing label from a recent issue. Allow four weeks for change to become effective. Claims for missing numbers will not be allowed if loss was due to failure of notice of change of address to be received in the time specified; if claim is dated (a) North America: more than 90 days beyond issue date, (b) all other foreign: more than one year beyond issue date; or if the reason given is "missing from files."

Subscription Rates 1988. Printed editions: nonmembers U.S. 1 yr. $49, 2 yr. $83, outside U.S. 1 yr $75, 2 yr. $135. Air freight rates available on request. Rates above do not apply to nonmember subscribers in Japan, who must enter subscription orders with Maruzen Co. Ltd., 3-10 Nihonbashi 2-chome, Chuo-ku, Tokyo 103, Japan. Tel: (03) 272-7211. Single copies: Current $7.00. Rates for back issues and volumes are available from Microforms & Back Issues Office, ACS, 1155—16th St., N.W., Washington, D.C. 20036. Back and current issues available on microfilm and microfiche. Rates on request from Microform Program, ACS.

Chemical & Engineering News (ISSN 0009-2347) is published weekly except for the last week in December by the American Chemical Society at 1155—16th St., N.W., Washington, D.C. 20036. Second-class postage paid at Washington, D.C., and additional mailing offices. POSTMASTER: Send address changes to Chemical & Engineering News, Membership & Subscription Services, P.O. Box 3337, Columbus, Ohio 43210. ACS assumes no responsibility for the statements and opinions advanced by the contributors to its publications.

Advertising Management
CENTCOM LTD.
(For list of offices see page 59)

LETTERS

Exposure to carcinogens

SIR: This is a comment arising out of your article on proposed Environmental Protection Agency benzene rules (C&EN, Aug. 22, page 22).

The problem with setting rules for protecting human beings from possible carcinogens is that it is difficult to determine what the response of the human is to a particular chemical at particular levels. I believe that Homo sapiens is the toughest animal on Earth. This arises from our ancestors' multimillenia-long exposure to multiple carcinogens in smoky caves and their habit of eating everything that came to hand (that didn't eat them).

In the case of benzene, an experimental animal is available—the chemist. My generation of chemists was exposed to frequent encounters with benzene in chemistry labs over many years. It was regarded as a fine solvent for removing oily or tarry soil from the body or clothes with little regard to ventilation. Other materials such as carbon tetrachloride were treated similarly. Surveys of older chemists do not reveal atypical mortality.

This is not to say that acute exposures should be ignored, but as Bruce Ames of the University of California, Berkeley, has told us, we are chronically exposed to a much greater number of natural carcinogens (and have been for eons) than synthetic ones, and we should not go overboard in setting rules and regulations for the latter.

A. C. Nixon
Berkeley, Calif.

High school chemistry

SIR: Relative to the ACS Comment "ChemCom—an exciting new approach to teaching" (C&EN, Sept. 26, page 47), I offer my own high school chemistry teaching experience.

I obtained my B.S. in chemical engineering in 1928. During the depression years I taught in the fifth and sixth grades, then college general and organic chemistry, and received an M.S. in education. Thereafter, I worked in the protective coatings industry to eventually become the technical coordinator of the vice president of research and development, production and marketing, for the three plants of a Canadian firm.

Returning to the U.S. I taught physics and chemistry in high school for 14 years and community college chemistry for two of those years before I retired in 1973. I was fortunate to enter this profession at the time of Sputnik, and participated in the National Science Foundation's summer sessions in chemistry (Chemical Bond Approach, Chemstudy), physics (Physical Science Study Committee), and mathematics. However, it became apparent that, in the high school where I taught, more modes of teaching chemistry were desirable. So I developed and taught (1) Advanced Placement Chemistry, 12 to 16 students, who used a library of college chemistry texts for their presentation of selected pertinent topics and laboratory research into relevant objectives; (2) science-oriented chemistry, 24 to 26 students, with a more sophisticated high school chemistry text backed up by a high school chemistry library, and with an appropriate lab manual and problem exercise book; (3) liberal arts chemistry, 24 to 26 students, with a more general high school chemistry text and lab manual and library; and (4) "Living Chemistry," 16 to 20 students (nonacademic), with the text and lab manual, "Living Chemistry," supplemented by wider lab work (it was predominantly a lab course), to acquaint them with objects they meet in everyday life, a number of which they made in the lab. The second mode might have been separated into a chemistry/biology-oriented and a physics-oriented mode.

My requirements (appropriate to the mode) were demanding, yet my classes were readily filled and well attended (the parents played a role). And the appreciative comments of students (and their parents), after graduation, from all four modes indicated that many (if not all) did benefit by the divisions.

I realize that many high school systems cannot make such divisions because of population size, teacher availability, financial limitations. More individual or subgroup attention by the properly trained teacher, aided by mimeographed text and lab literature (perhaps supplied by ACS), with lab materials supplied by industry, and the assistance of chemistry-oriented (or advanced-placement level) students, might serve. The content would need to be updated periodically.

Those were challenging, rewarding years!

Hubert A. Kraus
Cinnaminson, N.J.

Correction

• Oct. 31, page 7: Arco Chemical's trial production run of superabsorbent fiber at Du Pont will be for 200,000 lb of fiber, not 2000 lb; a commercial-scale facility would produce an estimated 20 million lb of fiber per year, not 20,000 lb.

Analytical Instrumentation Market Growing Rapidly

Spurred by industry, academia, and government needs for increased chemical analysis, global sales have nearly doubled since 1983

Ann M. Thayer,
C&EN Northeast News Bureau

The market for analytical instruments is showing a strength only dreamed about as little as five years ago. Driven by the need for greater chemical analysis coming from quality control and government regulation, a robust export market, and new and increasingly sophisticated techniques, sales are increasing rapidly.

The analytical instrument business' worldwide sales are nearly double their value of five years ago, reaching $4.1 billion in 1987. Such growth is in stark contrast to the doldrums of several years ago when economic recession held back sales growth to little or nothing. In recent years, the instrumentation market has recovered, growing at nearly 9% per year, and it's expected to continue at this rate at least until the 1990s. With sales increases exceeding inflation, the industry has seen real growth demonstrating the important role of chemical instrumentation in areas such as research and development, manufacturing, defense, and the environment in a technologically advancing world.

Worldwide sales figures for analytical instruments have been compiled and analyzed in a study by the technical and marketing consulting firm of Alpert & Sutcliffe, located in Stamford, Conn. According to its figures, in the U.S. alone, 1987 purchases of instrument lines having broad, general application to chemical analysis totaled about $1.62 billion and likely will reach $1.76 billion in 1988 after the 8 to 9% growth expected. This does not include equipment designed solely for clinical use, process control or monitoring, or special applications. Although exact import and export figures for specific types of instruments are difficult to obtain, close observers of the analytical instrumentation market indicate that U.S. exports still outweigh imports, although not overwhelmingly.

Competition now comes from overseas producers who have become technologically mature, whereas the technology for scientific instrumentation was once rooted almost entirely in the U.S. Figures from *Analytical Instrument Industry Report*, a British bimonthly newsletter, show the U.S. supplying 40 to 45% of the world market, Europe 25 to 30%, and Japan more than 20%. Of the top worldwide instrument manufacturers—those having sales over $100 million per year—five are U.S., five are European, and four are Japanese, based on rankings from the report. The instrument industry is becoming increasingly global and the position of the U.S. as a leader is apparently eroding.

Japan has increased its share in the instrument market over the past few years by capitalizing on trends in automation, computerization, and robotics, possibly more so than through innovations in analytical techniques themselves. Although the Japanese are making significant inroads into the market, exact sales figures can be deceptive. For example, Gordon Wilkinson, editor and publisher of the *Analytical Instrument Industry Report*, says that higher rankings of the Japanese companies, such as Shimadzu (1987 sales of $350 million to $400 million), are due primarily to the appreciation of the yen since 1985. Actually, these companies have had difficulties in export sales for the very same reason. However, the Japanese dominate sales in their own regional market, importing only $200 million from the U.S. and Europe, while consuming about 75% of the nearly $1 billion Western Pacific market. Japan is also the biggest supplier to China, the second

Operator uses Varian's LC Star System computer-controlled high-performance liquid chromatograph

largest consumer in the Western Pacific arena.

In spite of this, suggests Nelson L. Alpert, director of Alpert & Sutcliffe, the U.S. instrument industry can remain robust by maintaining the practice of close communications between manufacturers and users of the instruments. He says that historically this strong foundation has kept the U.S. instrumentation industry somewhat immune to economic and trade variations and has allowed it to lead in innovations and developments in technology through the interaction with customers.

Certain forces driving the instrumentation market can be detected in an altogether prosperous chemical industry. The materials, environmental, biomedical research, biotechnology, and pharmaceuticals sectors of the chemical industry are thought to have tremendous potential as consumers of instruments for their R&D efforts. Pharmaceuticals, a high return-on-equity business, put a large percentage, about 10%, of nearly $38 billion in earnings back into R&D in 1987, as compared with an average of 4.5% for the chemical industry as a whole. Biotechnology companies, although showing little if any in the way of profits, are expected to boom in the next decade along with extensive R&D efforts.

In remarks made before a recent meeting of financial analysts, Allen J. Lauer, instrument group president of Varian Associates Inc., mentioned these influences on the market. He said that the focus of Varian's instrument group, which produces chromatographs and spectrometers for industrial, research, and government laboratories, is on broadening its product line in carefully selected technologies in an attempt to leave the company well-positioned to serve the faster-growing life science, pharmaceutical, and environmental markets.

Apparently, this philosophy is working. Sales for Varian's instrument group are up 20% from last year, with a projected total of $227 million in 1988 sales. This has been a strong rebound for Varian; it was only two years ago that plans were discussed to divest the company's instrument group. Since that time, the group has grown more than 30% with pretax earnings of $20 million, its largest profit in 25 years.

Similarly, Perkin-Elmer Corp., the world's largest instrument manufacturer (1988 sales expected to reach $484 million), is looking at growth in some of the same areas. Perkin-Elmer's chairman and chief executive officer, Horace G. McDonell, considers its 16% rise in 1988 sales to be especially significant "because growth was achieved in all geographic markets." And, he adds, "The Far East was especially outstanding, led by a 100% gain in orders for the year in Japan."

Meanwhile, sales for Hewlett-Packard Co., the second largest U.S. instrument maker, have more than doubled in the past five years to $388 million in 1987. The weak dollar has aided the U.S. instrument business and made exports more competitive on a price basis; however, the U.S. market itself is not always particularly strong. Much of the apparent growth based on dollar figures is evident for many manufacturers, Hewlett-Packard and Perkin-Elmer among them, with very large overseas markets.

Another factor affecting the market is the expanding demand for thorough, yet rapid, chemical analysis in industrial and research laboratories. This labor-intensive and time-consuming work and the lower cost of computers in the past decade have influenced the design and production of automated and com-

Analytical instrument sales will reach $4.8 billion in 1989

$ Millions*	1989	1988	1987	1986	1985
MOLECULAR ANALYSIS					
UV/visible spectrophotometers	$ 242	$ 232	$ 221	$ 211	$ 202
Fluorescence spectrometers	75	69	61	54	48
Spectropolarimeters/ORD/CD	14	13	12	11	10
Fourier transform infrared	200	176	148	122	98
Dispersive infrared	59	58	58	62	64
Raman spectrometers	14	13	11	10	9
Near infrared	60	54	48	43	36
Nuclear magnetic resonance	199	181	165	148	133
Gas chromatographs	544	503	465	430	395
High-performance liquid chromatographs	782	714	646	580	513
Ion chromatographs	136	108	85	65	50
Liquid chromatographs	262	253	243	232	223
Voltammeters	24	23	22	21	20
Mass spectrometers	416	375	337	302	271
Thermal analyzers	126	115	104	94	86
Densitometers	49	47	45	42	39
Scintillation counters	55	52	49	46	45
Titrators	67	64	60	55	50
Automated flow analyzers	32	30	28	26	24
ELEMENTAL ANALYSIS					
Atomic absorption	183	174	166	158	148
Plasma emission	156	139	124	112	99
Arc/spark emission	101	96	92	86	80
Energy dispersive x-ray	137	124	112	102	94
Wavelength dispersive x-ray	97	95	92	90	88
X-ray diffraction	71	69	69	66	66
Electron spectrometers	139	125	113	102	94
Electron microprobes	34	31	29	26	26
Transmission electron microscopes	129	122	116	110	104
Scanning electron microscopes	205	187	169	152	142
pH/ISE systems	147	139	131	123	115
Organic elemental analyzers	87	81	76	70	65
TOTAL	$4812	$4462	$4097	$3751	$3437

a In actual dollars for 1985, 1986, and 1987. Estimates for 1988 and 1989 are based on June 1987 dollars and include inflation. **Source:** Alpert & Sutcliffe

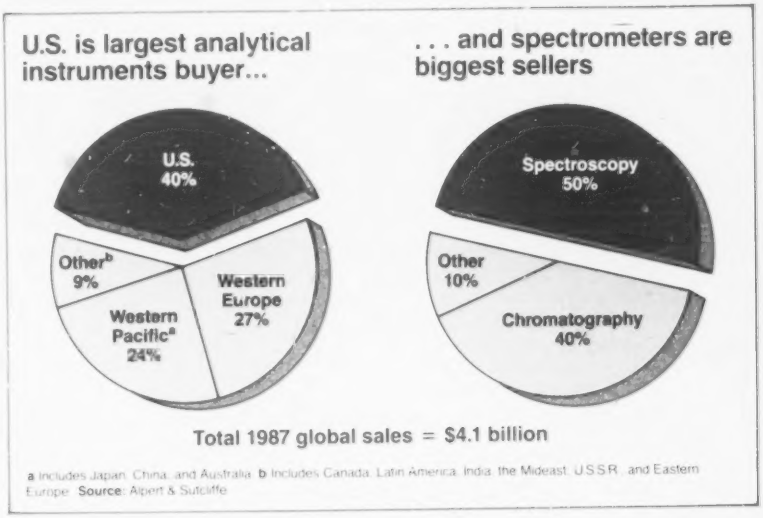
puterized analytical instrumentation. Computerization and automation are also becoming desirable for easy-to-operate, on-line process control and monitoring, quality control, and environmental testing. As big selling factors, many manufacturers now emphasize robotics, automation, software, computers, and the ability to interface equipment.

This trend is reflected in two ways. First, by the examples of Varian and Hewlett-Packard, both having nearly 50% of their R&D efforts in software development; Perkin-Elmer also focuses much of its effort on laboratory automation with its robotics hardware and with software systems for laboratory information management. And second, by the increased number of joint ventures or acquisitions that often combine instrumentation and computer technologies.

An example, but by no means the only one, is Perkin-Elmer. In the past two years it has broadened its base in chromatographic data handling and analysis through its acquisition of Nelson Analytical to form PE Nelson Systems, in biotechnology instrumentation through a joint venture with Cetus, and in environmental analysis through a joint venture with Sciex. Most recently, Perkin-Elmer and Digital Equipment Corp. have entered into a joint agreement for the marketing of laboratory information management systems.

Restructuring efforts are also hitting the instrument business. Currently involved in one is Beckman Instruments, the instrument division of SmithKline Beckman, which SmithKline is spinning off into a separate, publicly owned company. This has led to the sale of $5 million worth of Beckman shares, thereby decreasing SmithKline's interest in the company to 83%.

Analytical instrument sales in the U.S. are made chiefly to industry, followed by government and academia. Overall R&D spending in the U.S. has increased over the past decade to a level of $128 billion in 1988. Alpert indicates that increases in federal spending have done little to help the instrument business. Appropriations increases have gone primarily into the one third of total R&D spending that is for defense, an area whose R&D efforts give essentially no support to the purchase of smaller-scale instrumentation.


U.S. is largest analytical instruments buyer...
U.S. 40%
Other[b] 9%
Western Pacific[a] 24%
Western Europe 27%
. . . and spectrometers are biggest sellers
Spectroscopy 50%
Other 10%
Chromatography 40%
Total 1987 global sales = $4.1 billion
a Includes Japan, China, and Australia. b Includes Canada, Latin America, India, the Mideast, U.S.S.R., and Eastern Europe. Source: Alpert & Sutcliffe

Although it is difficult to come up with an exact total amount for government grants used for the purchase of instruments, it is evident that federal appropriations for research are increasing less quickly than in the past. Nonetheless, several tens of millions of dollars are slated specifically for the purchase of instruments. For instance, the Department of Energy has $5 million to spend on its instrumentation program each year. The University Research Initiative Program of the Department of Defense includes $25 million to be used only for the purchase of research instruments. In addition to shared instrument grants at about $32 million, the National Institutes of Health funds a $45 million program for the development of biomedical research apparatus. The chemistry division of the National Science Foundation hopes to spend nearly $18 million on instrumentation grants, $11 million of which is for undergraduate education. This money is becoming available slowly; some of the 1988 NSF proposals are just beginning to be funded in fiscal 1989. And authorized but not funded in the trade bill recently passed by Congress is $85 million for the upgrading of college and university research facilities (C&EN, Aug. 8, page 6).

Despite funding delays, economic ups and downs, and business dealings, some new technologies and innovations still manage to appear in analytical instruments. Recent developments have been in automation, data handling and analysis, and in the combining or "hyphenating" of techniques.

Most existing instrument lines show at least some growth, several being at or above the level of growth of the entire market. A general survey of the market suggests that all instrument lines have been helped by increased computerization and spreading application in growing industrial markets. Of 31 instrument types surveyed by Alpert & Sutcliffe, those based on molecular analysis constitute 69%, or $2.8 billion, of 1987 sales, and elemental analysis, 31%, or $1.3 billion in sales. Market share of various instrument lines differs geographically as do the dominant manufacturing centers.

Chromatography is the fastest-growing area, comprising 40%, or $1.5 billion, in 1987 world sales. Chromatographic methods are used extensively in industrial labs, which purchase about 70% of the devices made, for separation, purification, and analysis. One of the biggest words in all forms of chromatography is "biocompatibility." Biocompatible instruments are designed to have chemically inert, corrosion-resistant surfaces in contact with the biological samples.

The largest U.S. sales of individual instrument types go for high-

performance liquid chromatography (HPLC) and gas chromatography (GC) instruments, with $276 million and $175 million in 1987 sales, respectively, the Alpert & Sutcliffe study shows. HPLC sales have grown at rates of at least 10% over the past few years, although the market is maturing domestically and currently is growing at about 8%. The higher-cost, but more efficient, HPLC technology has nevertheless caused sales of more standard liquid chromatographs (LC) to flatten.

Again, it is biotechnology and new drug development efforts that are expected to affect HPLC sales. Expectations are that large scaleups of fermentation and genetic engineering will lead to increased use of HPLC instruments. In addition, the developing market for on-line monitoring, process control, and quality control has been predicted to be as large as $90 million in sales. Millipore/Waters Chromatography, the third largest U.S. instrument company with sales of more than $200 million in 1987 and 1988, has introduced one of the first on-line HPLC systems for process control.

Gas chromatograph sales are growing at about the same rate as the instrument market. Some of the newest innovations in GC technology are the production of more instruments with high-efficiency, high-resolution capillaries and supercritical fluid capability. Despite having only a 3% share of the GC market, supercritical fluid chromatography (SFC) has attracted a great deal of attention since its introduction around 1985 and production of the first commercial instrument around 1986. SFC, which operates using a supercritical fluid as the mobile phase, bridges the gap between GC and HPLC. The use of these mobile phases allows for higher diffusion rates and lower viscosities than liquids, and a greater solvating power than gases.

Another area showing tremendous growth is ion chromatography (IC). From growth levels of 30% per year in the U.S. and similar levels worldwide, the rate is expected to drop slightly but remain high at 25%. IC's popularity has been enhanced through extending its applicability from inorganic systems to amino acids and other biological systems by the introduction of biocompatible instruments.

Mass spectrometry (MS) sales have been growing about 12% annually. Sales have always been high, especially since MS is the principal detector in a number of hyphenated techniques such as GC-MS, MS-MS, and LC-MS. GC-MS accounts for about 60% of MS sales since it is used widely in drug and environmental testing. Innovations in interface technology such as inductively coupled plasma/MS, SFC/MS, and thermospray or particle beam interfaces for LC-MS have both advanced the technology and expanded the interest in applications. Recent introductions of lower-cost MS instruments with automated sampling and computerized data analysis have added to the attractiveness of the technique for first time users.

Spectroscopy accounts for half of all instrument sales and is the largest overall category of instruments, the Alpert & Sutcliffe study shows. It can be broken down evenly into optical methods and electromagnetic, or nonoptical, spectroscopies. These categories include many individual high-cost items such as MS, nuclear magnetic resonance spectrometers, x-ray equipment, and electron microscopy and spectroscopy setups. Sales of spectroscopic instruments that are growing at or above the market rate include Fourier transform infrared (FTIR), Raman, NMR, plasma emission, and energy dispersive x-ray spectrometers. Others have matured and slowed down in growth, but may still hold a large share of the market.

FTIR spectrometers have been a popular instrument line for the past few years. Their sales last year amounted to $148 million. This area has had 20 to 30% growth per year in the U.S., but levels are now reaching a more moderate 12%. The U.S. led in development of the technology and, following the usual trends, then showed tremendous growth and led in sales. This spurt in growth is now occurring in other markets as the instrumentation is adopted for use. The Western Pacific market is increasing at 35 to 45% a year, aided by the introduction of instruments from overseas manufacturers such as the Japanese. The number of suppliers of FTIRs worldwide is large and, with tough competition, the cost per instrument has recently dropped below $20,000. This bodes ill for dispersive IR instruments, sales of which have decreased 8 to 10% because of competition with the faster, more sensitive, and computerized FT methods.

Most of the larger-growing instrument lines see the same general trends affecting the market, according to the Alpert & Sutcliffe report. Plasma emission spectrometers had the typical rapid growth after the recession characteristic of a young technique. Sales have now leveled off to about 11% growth, but remain strong as ICP devices continue to compete with the not-so-strong atomic absorption techniques. NMR spectrometer sales are growing because of new applications in biomedical research and based on more sophisticated experimental methods using increased computing power. Similarly, Raman spectroscopy, traditionally used in academic research, is gaining in acceptance in industrial R&D and quality control but is doing so from a small sales base. Materials research and surface analysis in a variety of industries keeps sale of the electron microscopic, electron spectroscopic, and x-ray techniques growing.

The future of analytical instrumentation does not appear to be without its new stars as there continue to be innovations and developments in existing technology. Among these are the introduction of FT Raman, IR dichroism, IR microscopy, and NMR imaging spectrometers. Hyphenated and automated apparatus are also appearing on the market more frequently. New analytical techniques like capillary electrophoresis, gel capillary electrophoresis, scanning tunneling microscopy for the imaging of conducting systems, atomic force microscopy for the imaging of biological systems, and other techniques for surface and materials analysis are already, or may soon be, appearing as commercialized instruments. And, if the chemical industry continues to do well in the next few years, so too will the sales of analytical instrumentation. □